E C O N O M I C S   B U L L E T I N

Do exchange rates in caribbean and latin american countries exhibit nonlinearities?

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Abstract

This paper applies the recently developed Kapetanios et al. (2003) nonlinear stationary test to annual time series data on real exchange rates in selected Caribbean and Latin American countries over the period 1980-2003, to determine whether or not these real exchange rates exhibit nonlinearities. Generally, the ADF rejects the null hypothesis of a unit root in real exchange rates for most of the countries in our study, whereas the Kapetanios et al. (2003) test fails to reject the null hypothesis of a unit root in real exchange rates for most countries. The fact that the real exchange rates in most of the countries included in our study are nonlinear stationary implies that the nominal exchange rate and relative price are cointegrated irrespective of which price indices are used to compute the real exchange rate.

This paper is not under consideration by any other journal.
Citation: Francis, Brian and Sunday Iyare, (2006) "Do exchange rates in caribbean and latin american countries exhibit nonlinearities? ." *Economics Bulletin,* Vol. 6, No. 14 pp. 1-20
Submitted: September 7, 2005. **Accepted:** October 30, 2006.
URL: http://economicsbulletin.vanderbilt.edu/2006/volume6/EB-05F30009A.pdf

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Do Exchange Rates in Caribbean and Latin American Countries Exhibit Nonlinearities?

Abstract

This paper applies the recently developed Kapetanios et al. (2003) nonlinear stationary test to annual time series data on real exchange rates in selected Caribbean and Latin American countries over the period 1980-2003, to determine whether or not these real exchange rates exhibit nonlinearities. Generally, the ADF rejects the null hypothesis of a unit root in real exchange rates for most of the countries in our study, whereas the Kapetanios et al. (2003) test fails to reject the null hypothesis of a unit root in real exchange rates for most countries. The fact that the real exchange rates in most of the countries included in our study are nonlinear stationary implies that the nominal exchange rate and relative price are cointegrated irrespective of which price indices are used to compute the real exchange rate. More importantly, our empirical findings are supportive of Purchasing Power Parity (PPP) and are more vigorous than previous studies based on the ADF test, which did not take into account potential nonlinearities associated with real exchanges. A major implication of our finding is that within the context of Caribbean and Latin American economies, the simple PPP exchange rate model can be extended into monetary exchange rate models in a nonlinear manner to capture the nonlinear feature of real exchange rate behavior.

1. Introduction

The Purchasing Power Parity (PPP) conjectures that nominal exchange rates adjust to reflect differences in price levels across countries (Liew et al. 2005). By this hypothesis, the exchange rate between currencies of any two economies should equalize the relative price levels in these economies, provided that the effects of trade barrier and transaction costs are negligible (Liew et al.2005). Indeed, Liew et al. (2005) notes that PPP long run equilibrium is a useful benchmark in the setting of exchange rate parities or in the judging of exchange rate misalignment.

Yet, as Goh and Mithani (2000) document, inconclusive results from empirical assessments of PPP have encouraged further research along methodological lines. A major methodological problem associated with previous studies relates to the use of the ADF unit root test of PPP. Some of the main difficulties with the ADF test include the existence of structural breaks in the data generating process, failure to appropriately capture and incorporate cross-sectional effects when using panel data, and inadequacy in addressing potential nonlinear stationarity in the real exchange rate (Liew et al. 2005).

The desire to address the problem of potential nonlinear stationarity in real exchange rates from an econometrics perspective using recent techniques, and the need to ascertain whether results from other studies are consistent or inconsistent with real exchange rate characteristics in Caribbean and Latin American countries, are the main motivation for our study. Indeed, several factors account for the importance of examining the issue of nonlinear stationarity in real exchange rates in Caribbean and Latin American countries. First, there is a relative paucity of studies on exchange rate characteristics in Caribbean and Latin American countries (particularly for Caribbean countries). Second, Latin American countries have been subject to episodes of pronounced turbulence due to structural change, political and economic unrest, and fiscal and monetary reforms (Holmes, 2002). This factor is also relevant to several Caribbean countries such as Barbados, Dominica, Grenada, Guyana, Jamaica, and Trinidad and Tobago. Third, mixed results from previous empirical studies on the validity of PPP for LDCs (Holmes, 2002). Fourth, the ability to apply a more recent test for nonlinear stationarity in real exchange rates.

The empirical literature has much to say in recent times about the nonlinear stationarity of real exchange rates. A number of studies have provided evidence on unit root tests and the nonlinear adjustment of exchange rates (Baum et al., 2001; Kapetanios and Shin, 20031; Sarno, 2000). While evidence of nonlinear adjustment may not imply nonlinear mean reversion, it raises a series of fundamental questions concerning the ability of the conventional tests such as the augmented Dickey-Fuller (ADF) unit root test to detect any mean reverting tendency. The current literature offers some insights into these fundamental questions based on a nonlinear stationary test advanced by Kapetanios et al. (2003), hereinafter referred to as the KSS. A central empirical result from the KSS is that one can now reject linearity of exchange rates' behaviours based on linearity tests, and draws conclusions on the nonlinearly stationarity behavior of these exchange rates.

Indeed, few tests of this KSS have appeared in the literature; exceptions include Kapetanios et al. (2003), and Liew et al. (2004). Both studies provide evidence to support KSS test ability to reject unit roots in many series as compared to the augmented Dickey-fuller test. If KSS exhibits the power as these studies suggest, there is an incentive to subject the KSS test to more data. Consequently, our study applies the KSS test to annual time series data on real exchange rates in selected Caribbean and Latin American countries. In the Caribbean, understanding the long run relationship between nominal exchange rate, domestic prices, and foreign prices will be at the very heart of the equilibrium exchange rate determination as the region moves towards a single currency.

Against this background, the plan of the paper is as follows. Section 2 presents some of the theoretical arguments to explain how nonlinear stationarity or nonlinearities might arise in real exchange rates. Section 3 explains the two empirical testing frameworks adopted in our study. Section 4 discusses the data and empirical findings. Conclusions are presented in the final section.

2. Theoretical Perspectives

The economic literature has very little to say in terms of an underlying theoretical justification for the existence of nonlinearities in exchange rates. In fact, the linear approximations replete in the literature are only a matter of convenience for mathematical tractability and econometrics practice (Bleaney and Mizen, 1996). Bleaney and Mizen (1996) contends that linear approximations are useful in certain circumstances, but such approaches fail to capture critical characteristics of the data, especially if the mean-reverting component of the dynamics displays nonlinear patterns with respect to the level of the variable, due possibly to uncertainty about the true equilibrium. This belief with respect to the foreign exchange market forms the building block of their theoretical perspective. The essence of the theoretical argument put forward by Bleaney and Mizen (1996) is that if a currency is clearly overvalued or undervalued, betting on fundamentals may be an attractive venture for some traders to pursue. However, in the presence of uncertainty over the direction in which a currency needs to move in order to return to equilibrium, mean-reverting behavior may be weak within the range of uncertainty about the true equilibrium. Hence, Bleaney and Mizen (1996) concludes that a linear model cannot incorporate this possibility since it imposes a constant coefficient over the whole range.

Additionally, Ma and Kansas (2000) presents a brief synopsis of several theoretical models advanced by economists to explain observed nonlinearities in exchange rates. One of the more interesting theories is the target zone model. The target zone model links the existence of nonlinear behavior to the relationship between the exchange rate and its fundamental determinants. The essential argument is that once the exchange rate becomes misaligned with its fundamentals, provided that such deviations from the fundamentals is within a certain tolerance range, the exchange rate will display some degree of mean-reversion, with an adjustment speed that varies with the size of the deviation. This process accounts for the nonlinear adjustment of exchange rate towards the fundamental.[1]

Furthermore, Holmes (2002) explains that the existence of nonlinearities in real exchange rates is sometimes linked to the heterogeneity of participants in foreign exchange markets, specifically in relation to agents' expectations formation or investors' objectives. Conversely, Holmes (2002) continues, there is the possibility of arbitrage being limited by the presence of transactions costs in the event of relatively moderate real exchange rate shocks. Moreover, nonlinearities may arise within an equilibrium framework from policy changes within the context of trade reform, and fiscal policy.

[1]See Liew et al. (2005) and Ma and Kansas (2000) for further discussions of the target zone model.

3. The Empirical Testing Frameworks

3.1. The ADF Test

The standard augmented Dickey-Fuller (ADF) test with the inclusion of a constant and a trend can be represented mathematically as:

$$\Delta X_t = \alpha_0 + \alpha_1 t + \theta_1 X_{t-1} + \sum_{j=1}^{m} \beta_j \Delta X_{t-j} + \varepsilon_t \quad (1)$$

where $\Delta X_t = X_t - X_{t-1}$ and X_t is the variable under consideration; m is the number of lags in the dependent variable, which is chosen so as to induce a white noise error term; and ε_t is the stochastic error term. The stationarity of the variable is tested using the null hypothesis of $| \theta_1 | = 1$ against the alternative hypothesis of $| \theta_1 | < 1$. The critical values of ADF statistic as reported in McKinnon (1991) can be used to test this null hypothesis. Failure to reject the null hypothesis implies that the time series is nonstationary at a given significance level and, therefore, it requires taking first or higher order differencing of the level data to establish stationarity.

We use Akaike's Minimum Final Prediction Error (FPE) Criterion to choose the optimal lag length in the ADF test. Akaike's Minimum FPE is formulated as follows:

$$FPE = \frac{(T+K)}{(T-K)} * \frac{SSR}{T} \quad (2)$$

where T is the sample size, and K is the number of parameters estimated. SSR is the sum of the squared residuals. We compute the minimum FPE by regressing the time series in question on its own past and determine the optimum lag structure for that series.

3.2. Kapetanios et al. (2003) Test

The following, from Kapetanios et al. (2003), characterises the three equations they proposed for detecting the presence of nonstationarity against nonlinear, but globally stationary exponential smooth transition autoregressive (ESTAR) process:

$$\Delta y_t = \gamma y_{t-1}[1 - \exp(-\theta y_{t-1}^2)] + \varepsilon_t \quad (3)$$

where y_t is the demeaned series of interest, and ε_t is i.i.d. error with zero mean and constant variance. $\theta \geq 0$ is referred to as the transition parameter of the ESTAR model that directs the spread of transition. By focusing on a specific parameter, θ, which is zero in the case of the null hypothesis, and positive in the case of alternative hypothesis, we have: $H_0 : \theta = 0$ against the alternative: $H_1 : \theta > 0$.

As observed by KSS, testing the null hypothesis directly is not feasible due to the problem of identifying γ under the null hypothesis. To overcome this problem, they reparameterised Equation (3) based on a first-order Taylor series approximation to the ESTAR model under the null as:

$$\Delta y_t = \delta y_{t-1}^3 + error \quad (4)$$

or:

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j y_{t-j} + \delta y_{t-1}^3 + error \quad (5)$$

Equation (5) corrects for plausible serially correlated errors. Following KSS, and Liew et al. (2004), we fix $\rho = 8$ in the present study, and in both cases, test the null hypothesis $H_0 : \delta = 0$ against the alternative hypothesis $H_1 : \delta > 0$. It is important to notice that the t statistic of the parameter of interest (in this case, δ) does not assume an asymptotic normal distribution. Hence KSS suggested simulations for asymptotic values.

4. Data and Empirical Findings

This study utilises annual time series data on real effective exchange rates for selected Caribbean and Latin American countries, covering the period 1980-2003. All of the data were obtained from the World Bank World Development Indicators Online Database.[2] All the variables are in their natural logarithmic form, and demeaned.

Table 1 presents the results of the unit root tests using both the ADF with an intercept, and the KSS. The t statistics from Equations (4) and (5) are referred to as KSS1 and KSS2, respectively. These two t statistics are reported in the final columns of Table 1. Indeed, the empirical findings are mixed for both Caribbean and Latin American countries. The empirical results of the ADF reject the null hypothesis of a unit root in the real exchange rates for most of the countries in the Caribbean, except Guyana and St. Lucia, where the null hypothesis of a unit root in the real exchange rates is not rejected. For the Latin American countries, the ADF rejects the null hypothesis of a unit root in the real exchange rates for Venezuela.

However, the results from both KSS unit root tests generally fail to reject the null hypothesis of a unit root in most of the remaining Caribbean and Latin American countries. The only cases in which the KSS rejects the null hypothesis of a unit root in the real exchange rates are Belize, Grenada, St. Vincent and the Grenadines, and Costa Rica.

Generally, the ADF rejects the null hypothesis of a unit root in real exchange rates for most of the countries in our study, whereas the Kapetanios et al. (2003) test fails to reject the null hypothesis of a unit root in real exchange rates for most countries. The contradictions in findings from the two testing procedures are consistent with those of other studies found in the literature.

5. Conclusions

Our paper adopts two different unit root tests on real exchange rates in selected Caribbean and Latin American countries over the period 1980-2003 to determine whether or not these real exchange rates are stationary. These tests are: the standard augmented Dickey-Fuller (ADF) test, and the nonlinear stationary test developed by Kapetanios et al. (2003), denoted the KSS test. The KSS test models the real exchange rate behavior by using a globally stationary exponential smooth transition autoregressive (ESTAR) process. The empirical findings of the paper show that the ADF

[2]The World Bank defines the real effective exchange rate as the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. The countries selected, and the period of analysis, reflect data availability.

rejects the null hypothesis of a unit root in real exchange rates, while on the other hand, the KSS test fails to reject the null hypothesis of a unit root for most of the countries.

Since the test developed by Kapetanios et al. (2003) is a stationarity test for nonlinear models, and is deemed to have better power than the standard ADF unit root test for nonlinear series, from our empirical finding, we conclude that real exchange rates of the Caribbean and Latin American countries are not nonlinear stationary. Interestingly, the empirical findings of our paper are contradicting to the previous studies conducted on the unit root behavior in nonlinear models. Kapetanios et al. (2003) and Liew et al. (2005) find that ADF test results fail to reject the hypothesis of unit root in the real exchange rates; on the other hand, the nonlinear KSS test depicts stationarity. This contradictory result to these previous research may be attributed to differences in monetary policies and exchange rate regimes of Caribbean and Latin American countries. To be certain of the rationale for the differences in findings, further research has to be conducted.

Extrapolating from Liew et al. (2005), our inference implies that the nominal exchange rate and relative price are not cointegrated irrespective of which price indices are used to compute the real exchange rate. More importantly, and contrary to the results from Liew et al. (2005), our empirical findings, based on a more vigorous testing procedure than the ADF test, which does not take into account potential nonlinear stationarity associated with real exchanges, do cast doubt on Purchasing Power Parity (PPP). Furthermore, unlike Liew et al. (2005), a major implication of our finding is that within the context of Caribbean and Latin American economies, the simple PPP exchange rate model cannot be extended into monetary exchange rate models in a nonlinear manner to capture real exchange rate behavior.

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Table 1 Linear and Nonlinear Unit Root Tests Results for Real Exchange Rates in Selected Caribbean and Latin American Countries

Caribbean Country	**ADF**	**KSS1**	**KSS2**
Antigua and Barbuda (0)	-4.04***	-0.39	-1.47
The Bahamas (5)	-3.24**	1.24	-1.31
Belize (6)	-4.08***	-0.08	-5.82***
Dominica (8)	-4.26***	0.39	-1.85
Dominican Republic (0)	-4.34***	-1.25	-1.18
Grenada (5)	-3.13**	0.44	-3.78***
Guyana (4)	-2.38	-1.71	-1.85
St. Kitts and Nevis (0)	-2.78*	-0.09	-1.19
St. Lucia (8)	-1.34	0.25	-1.81
St. Vincent and the Grenadines (0)	-2.95*	0.01	-2.01*
Trinidad and Tobago (0)	-3.22**	-0.11	-1.52
Latin American Country			
Chile (6)	-2.18	-1.79	-1.89
Costa Rica (6)	-1.17	-1.02	-2.03*
Venezuela (0)	-3.87***	-0.73	-1.28

*,**, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Numbers in brackets are the optimal lag length determined using the Akaike Information Criteria (AIC).

Where the optimal lag length was zero, the KSS was applied using a lag of 1.

For critical ADF values, see MacKinnon (1991).

For the asymptotic critical KSS values of –2.82, -2.22, and –1.92 for the 1%, 5%, and 10% significance levels, respectively, for the raw data, see Kapetanios et al. (2003).